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(54) A centrifuge comprising a rotor with a shroud

(57) The centrifuge comprises a rotor (1) on a shaft, the rotor mounting pods (8) intended to receive one or more containers to be centrifuged. The rotor (1) comprises a shroud (3) surrounding the pods (8) the shroud (3) having holes (11) distributed over its contour, at the level at which the bases of the pods will lie under the forces at play when the rotor is rotating at its design speed.

These holes (11) create good internal air circulation between the interior and exterior of the rotor and thus assist temperature regulation, which is important for centrifuging of bio-medical samples. Heating a cooling device (16) regulates the temperature within the chamber (4) housing the rotor.

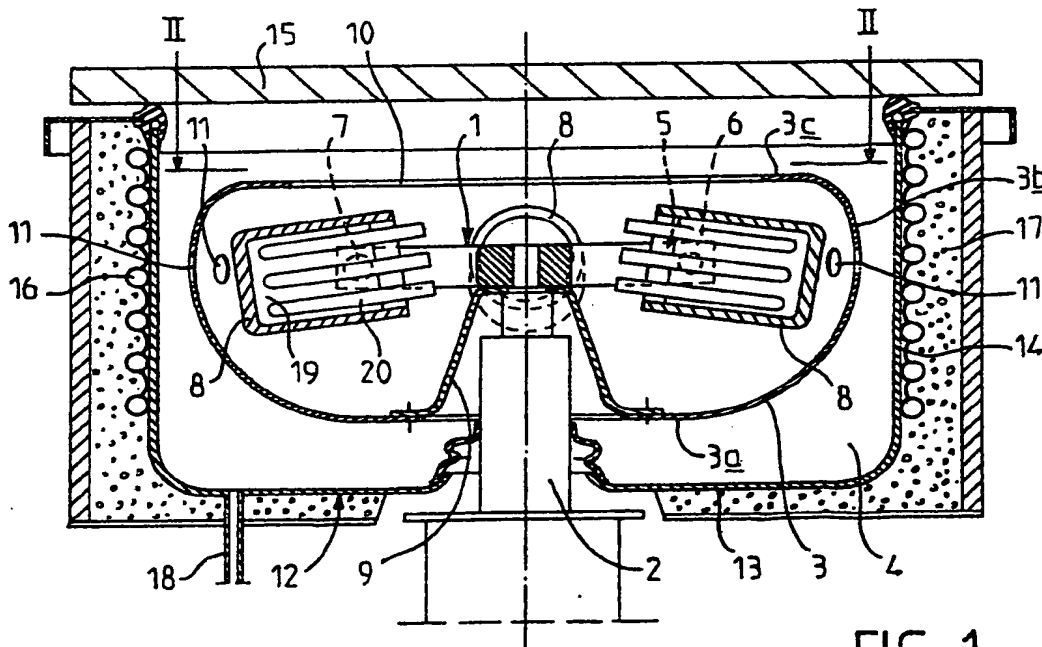


FIG. 1

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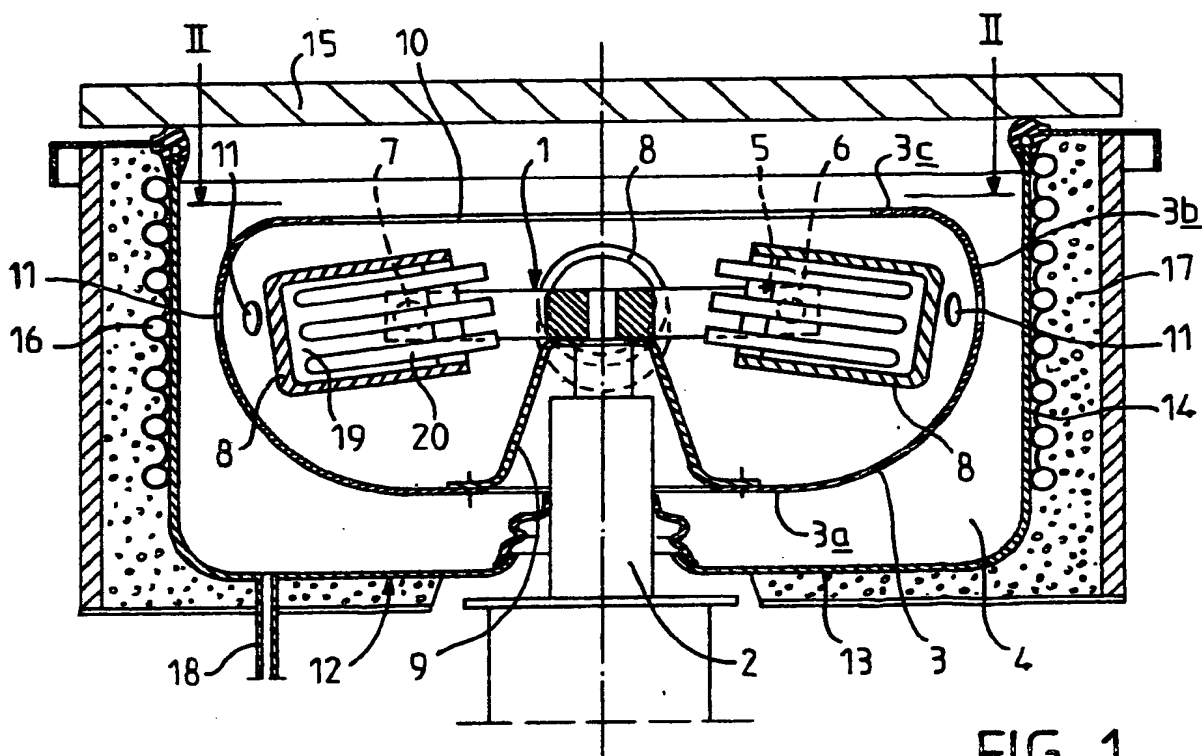


FIG. 1

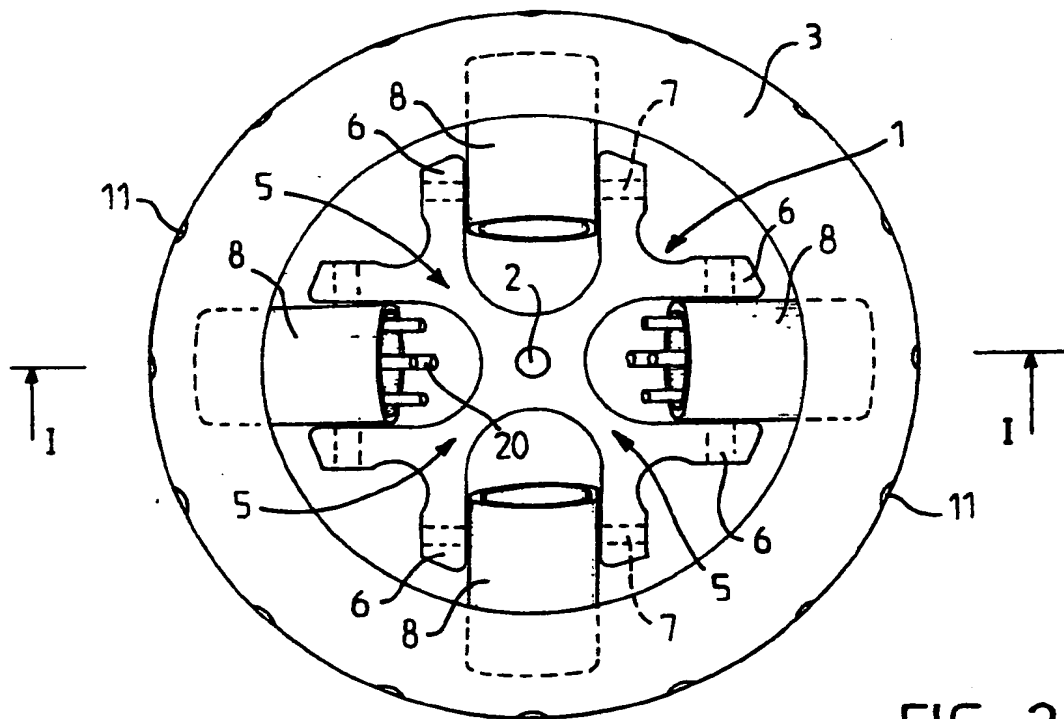


FIG. 2

A CENTRIFUGE COMPRISING A ROTOR WITH A SHROUD

The present invention concerns a centrifuge comprising a rotor with a shroud. Such centrifuges are used, for example, in biochemistry or medical applications, in particular for the processing of blood.

Such a centrifuge comprises a stator or vessel having a generally thermostatically controlled casing and a rotor driven in rotation in the casing by a motor. When a rotor is rotating in its casing, it tends to entrain the air contained in the casing. This is why such centrifuges frequently comprise a shroud surrounding the rotor, this shroud being fixed in relation to the rotor, being driven in rotation therewith, and having the object of preventing or at least reducing the excess and low pressure phenomena which may occur in the atmosphere of the vessel casing when the rotor is rotating. Without a shroud the rotor operates substantially as a centrifugal pump; this is particularly so with rotors currently called "star rotors" comprising several branches extending radially from the rotor shaft, with pods (intended to receive the containers to be centrifuged) mounted between said branches, the branches then behaving substantially like the blades of an impeller. The shrouds with which these rotors are provided thus allow the air turbulence created during the rotation to be reduced, and therefore reduce the energy losses and the heating resulting therefrom.

However, such shrouds have the major drawback of preventing a proper air circulation round the centrifuging pods; the heat exchanges between the outside of the shrouds and the pods are unsatisfactory. Now it is important to have the facility of controlling the temperature of these pods very precisely, in particular when the centrifuge concerned is used in medical applications or in biochemistry, since many biological products have to be kept at precisely determined temperatures which may be selected in the range from 4°C to 37°C. To permit a proper

temperature control of the pods, the rotor is frequently mounted, as indicated above, in a vessel casing whose walls are provided with refrigeration (and possibly with heating) devices. It should indeed be pointed out that practically
5 the whole motor output of the order of one kilowatt is dissipated as heat in the vessel, which necessitates the removal of calories to maintain the air temperature of the vessel at a given level. It is quite clear that the presence of a shroud establishes a separation between on the
10 one hand the air comprised between the vessel and the shroud, and on the other hand the air comprised inside the shroud. This results in an unsatisfactory adjustment of the temperature of the centrifuging pods, especially when the shroud is completely closed by means of a lid.

15 In German Patent 867 077, a centrifuge has already been disclosed wherein a centrifuging shroud comprises a cross piece carrying beakers wherein the product to be centrifuged is contained. This shroud comprises holes allowing the circulation of cooled air improving the
20 refrigeration effect; these holes are disposed near the shaft of the shroud and at its periphery. However, whatever the relative positioning of the holes of the periphery of the shroud and of the beakers containing the product to be centrifuged, such a device is not really efficient.
25

The present invention therefore proposes a rotor with a shroud permitting improved heat exchanges between the cooling or heating systems of the vessel and the centrifuging pods. To do this, the present invention
30 proposes to use a rotor shroud comprising holes distributed over the whole of its periphery: when the shroud does not include any lid, the said holes allow proper circulation of the air within the shroud during the rotational motion of the rotor and the Applicant has found that the optimum
35 efficiency was obtained when the holes were disposed on the side wall of the shroud at a level such that the bottom of

the centrifuging pods is located substantially at the level of the said holes, when the rotor is driven in its rotational motion; indeed, in turning, the shrouded rotor creates a high pressure zone at the periphery of the shroud and a low pressure zone at the centre, whence there results an air circulation through the holes of the shroud. The air in the vessel comes to sweep the refrigerated wall of the vessel casing, then returns to the centre of the shroud, comes to sweep the walls of the pods and reemerges through the holes at the bottom of the said pods, whence there results a substantial improvement of the heat exchanges.

Moreover, such holes allow liquids to be drained which the shroud may contain and which may be the cause of imbalances generating vibrations in the apparatus and stresses on the shaft of the rotor, which can cause the deterioration or even the destruction of the centrifuge. It is indeed possible for the containers to be centrifuged (test tubes, bags with flexible sides or similar) to break during the centrifuging under the effect of the high pressures generated by the centrifugal accelerations. When the vessel is brought to a low temperature, condensations may also occur inside the shroud, when the temperature in the shroud is equal to, or becomes less than the dew point of the moist air contained in the shroud; these phenomena too, may be the cause of imbalances endangering the apparatus. This is the reason why in accordance with the invention, a shroud of a particular shape is proposed; this shroud comprises a bottom parallel to the bottom of the pods when the rotor is at rest, the said bottom being connected via a flaring of revolution to a cylindrical portion wherein the holes are cut, the cylindrical portion extending on the opposite side to the bottom by an inner annular rim returning towards the shaft and delimiting a circular opening centred on the said shaft.

The object of the present invention is therefore a centrifuge comprising in a stator vessel casing, a rotor

movable in rotation around its shaft and driven by a motor, the said rotor carrying pods each intended to receive at least one container to be centrifuged, the said rotor being associated with a shroud which is fixed thereto and

5 surrounds it at least at the level of the said pods, the rotor and its shroud constituting an assembly dynamically balanced in relation to its rotation shaft, the pods being pots mounted on the rotor by swivel pins allowing them to swivel under the effect of the centrifugal force during the
10 rotation of the rotor, the shroud comprising a plurality of holes distributed over its lateral wall, characterized in that the holes are disposed on the side wall of the shroud at a level such that the bottom of the pods is situated substantially at the level of the hole when the rotor is
15 driven in its rotational motion.

Advantageously, the shroud comprises a bottom parallel to the bottom of the pods when the rotor is at rest, the said bottom being connected, by a flaring of revolution to a cylindrical portion wherein the holes are
20 cut, the said cylindrical portion being extended on the opposite side to the bottom in an inner annular rim returning towards the shaft and delimiting a circular opening centred on the said shaft; the rotor is advantageously a star-shaped rotor; the shroud may comprise
25 at least one hole per pod and in particular, one hole opposite each pod; to facilitate the dynamic equilibrium of the rotor, the holes may have the same diameter and be interspaced at a constant angular distance with respect to each other; the centres of the holes can be in the same
30 plane perpendicular to the shaft of the rotor or they can be at levels staggered in relation to each other in the direction of the shaft of the rotor.

The holes can be even or odd in number: generally, an odd number will be chosen if the noise during rotation
35 has to be reduced; the holes can have the same or different diameters; for the centrifuges of average size, it has been

found that good results were obtained by cutting holes having diameters of 8 mm. It is preferable for the holes to be substantially in the portion with the largest diameter of the shroud.

5 In order that the present invention may more readily be understood, one embodiment thereof will now be described merely by way of a purely illustrative and non-restrictive example, with reference to the attached drawings in which:-

10 Figure 1 is a sectional view, along line I-I of Figure 2, of a centrifuge in accordance with the invention, the section line I-I passing through the shaft of the rotor; and

15 Figure 2 is a plan view, along line II-II of Figure 1, of solely the rotor of the centrifuge of Figure 1.

Referring to the drawings, it will be seen that the illustrated centrifuge comprises a star-shaped rotor 1 turning round its shaft 2 and entraining a shroud 3 in its movement, the assembly being mounted in a stator vessel 4.

20 This star-shaped rotor 1 comprises four branches 5 extending radially from the rotation shaft 2 of the rotor, the branches 5 defining the a common median plane perpendicular to the said shaft 2, and being regularly distributed round the shaft. Each one of these branches 5
25 terminates at the end remote from the shaft 2 in two arms 6 symmetrically distributed in relation to the branch 5 which carries them and forming between themselves a fork whose opening angle is 45° . Each arm 6 of one branch 5 is parallel to the arm 6 of the adjoining branch 5 which it
30 directly faces, and carries moreover a swivel pin 7 extending perpendicularly, in the median plane of the star-shaped rotor 1 towards the facing arm 6. On the two swivel pins 7 of two opposite arms 6 terminating tw adjacent
35 under th effect of centrifugal forc in relation t the axis formed by the swivel pins 7 during the rotational

motion of the rotor 1. These pods 8 are pots intended to receive the containers to be centrifuged. The containers may consist of supports 19 whose external shape is complementary to the internal shape of the pods 8 and which are provided with cylindrical openings to receive the tubes 20 to be centrifuged; these containers may also consist of bottles or bags with flexible sides (not shown).

The branches 5 of the rotor 1 are made of a steel having a tensile strength of 80 to 100 Kg/mm², the star-shaped rotor 1 being able to support up to 24 tons per branch 5, its weight being 40 kg.

The shroud 3 comprises a wall formed as a body of revolution round the shaft 2, flaring substantially from a bottom 3a parallel to the bottom of the pods 8 when the rotor 1 and the latter are at rest, up to a substantially cylindrical portion 3b centred on the shaft 2. The bottom 3a is connected to the centre of the star-shaped rotor 1 by a frustoconical skirt 9 flaring from the rotor 1 to the bottom 3a, the said skirt 9 having its ends welded or riveted to the rotor 1 and to the shroud 3. The cylindrical portion 3b is the largest diameter portion of the shroud 3 and is situated substantially at the level of the median plane of the branches 5 of the rotor 1. The shroud 3 comprises, on this cylindrical portion 3b of the lateral wall constituting it, a plurality of circular holes 11 having a diameter of approximately 8 mm, the centres of these holes 11 being distributed substantially at the level of the median plane of the branches 5 of the rotor 1, the bottom of the pods 8 being situated substantially at the level of the holes 11 when the rotor 1 is driven in its rotational motion. Moreover the shroud 3 terminates, beyond the cylindrical portion 3b in relation to the bottom 3a in an inner annular rim 3c which delimits a circular opening 10 centred on the shaft 2 and whose radius is slightly greater than the largest radius of the assembly formed by the rotor 1 and the pods 8 when at rest. Such a

shroud 3 is obtained, for example, by the spinning of sheet metal.

The assembly constituted by the rotor 1, the shroud 3 and the pods 8 is mounted in a cavity 12 of the stator vessel 4, the vessel 4 comprising a bottom 13 surrounded by an upstanding cylindrical wall 14 and being able to be obturated in a leakproof manner by a lid 15. In the conventional way this vessel 4 is associated with a refrigeration (and/or heating) device 16 as well as a layer 17 which is made of an insulating material and externally surrounds the wall 14 and the bottom 13. A drain tube 18 passing through the layer 17 issues in the bottom 13 and allows liquids contained in the vessel 4 to be evacuated.

Such a centrifuge is used in the way that will now be described.

After the operator has introduced the containers 19 to be centrifuged through the opening 10 into the pods 8, and then replaced the lid 15 into its position obturating the vessel 4, the star-shaped rotor 1 is driven in rotation by means of a motor, at a speed which may be of the order of 10^4 to 10^5 r.p.m. at maximum. The air in the vessel 4 of the centrifuge is entrained in its turn and sweeps the wall 14, cooled (or heated) by the device 16, and is then aspirated by the pressure difference created between the periphery of the shroud 3 and its centre, and circulates through the holes 11 of the shroud 3, thus ensuring the cooling (or heating) of the pods 8 and of their contents.

It should be noted that in operation, the temperature difference between the pods 8 and the wall 14 of the vessel 4 is of the order of 2°C , whilst with a centrifuge which comprises a rotor whose shroud is without such holes this temperature difference may be greater than 10°C .

Moreover if, for n of the reasons set out above, the shroud 3 contains any liquid whatever, this liquid will during the rotation of the star-shaped rotor 1 be pressed

to the inner wall of the said shroud 3 and will rise as far as the cylindrical portion 3b of the shroud 3, which is the portion with the largest radius, to escape through the holes 11 and drop to the bottom 13 to be evacuated through the
5 drain tube 18.

As in the case of any use of a centrifuge, care will be taken to ensure that the deceleration of the centrifuge should not be too sudden, so that the products separated by the centrifuging should not be placed into a
10 suspension one in the other, this being the more important if the differences in their densities are small. By way of an indication of the values, one may pass from 4,000 r.p.m. to zero r.p.m. in three minutes, with a first rapid braking stage down to 800 r.p.m., followed by a second parabolically
15 damped braking stage. The end of the braking may, for example, be obtained by short circuiting the rotor of the motor driving the centrifuge rotor 1.

In other non-illustrated embodiments wherein an attempt is made to avoid more particularly the problems of
20 vibrations or of noise which may be generated by the existence of the holes in the shroud, the holes are at levels staggered one in relation to the other in the axial direction of the rotor, and/or are regularly distributed over the wall of the shroud, the shroud then being moreover,
25 rebalanced by an addition of mass. In yet other embodiments, the holes have different diameters, and/or there is an odd in number of them, to allow the formation of certain harmonics to be avoided.

C L A I M S

1 A centrifuge comprising a casing of a stator vessel, a rotor movable in rotation round its shaft and driven by a motor, said rotor carrying pods each intended to
5 receive at least one container to be centrifuged, said rotor being associated with a shroud which is fixed thereto and surrounds it at least at the level of said pods, the rotor and its shroud constituting an assembly which is dynamically balanced in relation to its rotation shaft, the pods being
10 pots mounted on the rotor by swivel pins allowing them to swivel under the effect of the centrifugal force during the rotation of the rotor, the shroud comprising a plurality of holes distributed over its side wall at a level such that the bottom of the pods is situated substantially at the
15 level of the hole when the rotor is driven in its rotational motion.

2. A centrifuge according to Claim 1, wherein the shroud comprises a bottom parallel to the bottom of the pods when the rotor is at rest, said bottom being connected by a
20 flaring body of revolution to a cylindrical portion wherein the holes are formed, and wherein said cylindrical portion is extended on the opposite side to the bottom in an inner annular rim returning towards the shaft and delimiting a circular opening centred on said shaft.

25 3. A centrifuge according to either of Claims 1 and 2, wherein the rotor is a star-shaped rotor.

4. A centrifuge according to any one of Claims 1 to 3, wherein the shroud comprises at least one hole per
pod.

30 5. A centrifuge according to Claim 4, wherein the shroud comprises a hole opposite each pod.

6. A centrifuge according to any one of Claims 1 to 5, wherein the holes are interspaced at a constant angular distance from each other.

35 7. A centrifuge according to any one of Claims 1 to 6, wherein the centres of the holes are in the same plane

perpendicular to the shaft of the rotor.

8. A centrifuge according to any one of Claims 1 to 6, wherein the centres of the holes are at levels staggered in relation to each other in the axial direction of the shaft of the rotor.

9. A centrifuge according to any one of Claims 1 to 8, wherein the holes are disposed substantially in the largest diameter portion of the shroud.

10. A centrifuge according to any one of Claims 1 to 9, wherein the holes have equal diameters.

11. A centrifuge according to any one of Claims 1 to 9, wherein the holes have different diameters.

12. A centrifuge substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawing.